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THE GEOLOGICAL DEVELOPMENT OF THE SOUTHERN SHORES AND ISLANDS OF BASS STRAIT

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ABSTRACT: The geology of the Tasmanian margins and islands of Bass Strait is reviewed in the light of recent work. Since its inception, the Bass Basin has played an important role in the geological development of the uplands. The later structure was probably inherited from mid-Jurassic times when intrusion of dolerite sheets uplifted the southern margin. Its early development as an *en echelon* graben was linked with spasmodic magmatism on the uplands, this igneous activity continuing into mid-Cretaceous times.

The main outlines of Bass Basin and associated upland troughs had formed by faulting by Paleocene times and thick sequences of non-marine sediments accumulated in these depressions. By late Eocene times restricted seas entered the basin, major faulting ceased and basic volcanism broke out along the Tasmanian uplands. Some upland troughs had become choked with thick sequences of subaerial lavas by late Oligocene times.

Miocene marine transgression onto Tasmania was impeded in troughs containing the older basaltic fills, but where the seas coincided with concurrent volcanism, the finest range of aquagene volcanic sequences known in the Australian Cainozoic formed up to heights over 120 m above present sea-level. The vigorous mid-Cainozoic volcanism produced both alkali basaltic and tholeiitic lavas and considerable volcanism also occurred following regression of the Miocene high seas and dissection of its deposits. The precise age of the later volcanism presents a problem still to be solved. The distribution of the Tertiary magma types appears to be structurally controlled with tholeiitic rocks developed over mantle upwarps along margins of the basin.

Since mid-Pliocene times at least, the Tasmanian margin of Bass Strait appears to have remained tectonically and volcanically relatively inactive. The later history has been mainly one of eustatic fluctuations controlling coastal depositional and erosional processes, particularly during glacial and interglacial phases. Old strand line deposits, largely related to interglacial higher seas, have been recognized up to heights of 45 m above present sea-level. Glacial meltwaters contributed cobble deposits at the outlets of the Mersey and Forth Rivers. Extensive dune building, both siliceous and calcareous in nature, has invaded favoured locations and since the rise of the post-Glacial sea well developed beach ridge systems have formed in some areas. The sea-level fluctuations influenced distribution of animal populations on Bass Strait coasts and isolated the Tasmanian Aborigine.

INTRODUCTION

Bass Strait extends over a major structural depression, the Bass Basin, which separates Tasmania from Victoria (Jennings, J., 1959a; Richards & Hopkins, 1969). This structure has strongly influenced the later geological history of north Tasmania as an outlet for major drainage, as a region of marine incursions and as a locus of igneous intrusion and volcanism. Bass Strait provides an extensive margin for coastal dune and littoral deposits and fluctuations in sea-level have regulated movements of land animals across it.

The first extended survey of the Tasmanian margin (Stephens, 1909) included a strip map of the coastal geology from the Tamar to Circular Head. Recent work now furnishes much new detail and understanding of the geological development of the shores and islands. The area considered in this paper (Fig. 1) is covered in its central part by the Geological Survey 1″ to 1 mile (1: 63,

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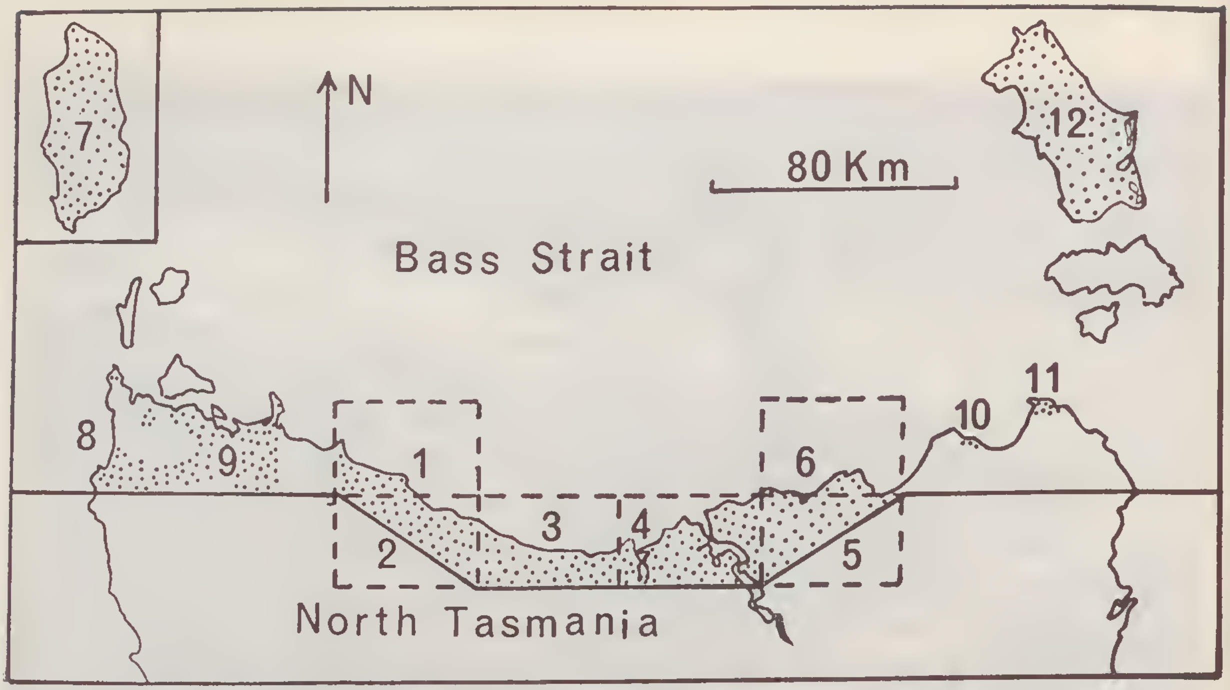

FIG. 1—Map showing islands and shores of southern Bass Strait. The area considered in the text lies above the thick line. Areas within, that are covered by recent published geological mapping (stippled zones), include 1" to 1 mile (1: 63,360) Sheets (1) Table Cape, (2) Burnie, (3) Devonport, (4) Beaconsfield, (5) Pipers River, (6) Noland Bay, and other mapping, (7) King Island, (8) Woolnorth-Marrawah, (9) Smithton, (10) Tomahawk, (11) Cape Portland, (12) Flinders Island.

360) mapping of the following sheets: (1) Table Cape (Gee, 1971); (2) Burnie (Gee et al., 1967); (3) Devonport (Burns, 1964); (4) Beaconsfield (Gee & Legge, 1971); (5) Pipers River (Marshall et al., 1969); (6) Noland Bay (Jennings, D., 1967). Further published mapping covers some other parts, namely: (7) King Island (Jennings, J., 1959b; Solomon, 1969); (8) Woolnorth (Sutherland & Corbett, 1967); (9) Smithton (Gulline, 1959); (10) Tomahawk (Moore, 1969); (11) Cape Portland (Jennings, D. & Sutherland, 1969); (12) Flinders Island (Sutherland & Kershaw, 1971). Unpublished mapping of several areas is also available and includes Clarke and Cape Barren Islands (J. Cocker, Ph.D. in prep., University of Tasmania) and bed rock geology of the Blue Tier Batholith (D. I. Groves) and the Tomahawk-Mt. Cameron area (D. I. Groves & D. J. Jennings, Tasmanian Mines Dept.)

Off-shore stratigraphic information within the Tasmanian part of the Bass Basin includes petroleum exploration drilling (e.g. Bass 1, 2 & 3; B.M.R. Petroleum Search Subsidy Rept. No. 83, 1965-1967). In the light of new data briefly incorporated in this paper previous correlations of sedimentary and volcanic Cainozoic successions along Bass Strait shores in northern Tasmania (Sutherland, 1969a) need some revisions, and these will be presented in detail elsewhere (Sutherland, in prep.).

The area is of economic importance and information of economic geological interest appears in unpublished reports by lease and exploration licence holders, held in the records of the Tasmanian Mines Dept. Tungsten and heavy mineral sands are worked on King Island (Knight and Nye, 1965; Jennings, I. et al., 1967), there are gold and tin deposits in north and north-east Tasmania (Noldart & Threader, 1965; Jack, 1965, 1966; Jennings, I. et al., 1967), but petroleum prospects in the Bass Basin are yet to be realized (Hopkins, 1966; Richards & Hopkins, 1969).

The margins of Bass Basin were initiated following tensional rupturing of eastern Gondwanaland in the mid-Mesozoic, contemporaneous with orogenesis along the continental margin (Griffiths, 1971). The thick dolerite sheets of Tasmania appear to terminate in southern Bass Strait. Dilation associated with their intrusion probably contributed to uplift of the southern margin. The dolerite invasion (165 m.y.; McDougall, 1961) marks a convenient event, dividing the geological development of the Tasmanian block into pre- and post-Bass Basin rocks.

PRE-BASS BASIN BASEMENT

This includes (i) Precambrian and Palaeozoic rocks that preceded the Tabberabberan Orogeny (about mid-Devonian; Spry & Banks, 1962), (ii) Upper Devonian to Lower Carboniferous post-orogenic granites (McDougall & Leggo, 1965), (iii) Upper Carboniferous to Lower Jurassic sedimentary cover and (iv) the mid-Jurassic dolerite intrusions.

Precambrian

Proterozoic rocks outcrop extensively on the NW. Coast and the islands (Jennings, J., 1959b; Gulline, 1959; Burns, 1964; Sutherland & Corbett, 1967; Solomon, 1969; Gee, 1971). They are largely unmetamorphosed successions of quartzose sandstone, siltstone, quartz wacke and minor lavas, traversed by subordinate belts of metamorphosed rocks that include quartzite, schist, amphibolite and stretched conglomerate. The Keith Metamorphics at Wynyard overlie and separate the Rocky Cape Group (5,730 + m thick) from the younger onlapping Burnie Formation (4,400 + m thick and formed in a separate depositional basin) and probably represent a high angled shear zone (Gee, 1968). Relationships of the Ulverstone and Forth Metamorphics are less clear and they may unconformably underlie the sedimentary successions (Burns, 1964). On west King Island, the beds are intruded and contact metamorphosed by granite at least 750 m.y. old (McDougall & Leggo, 1965). Doleritic and meta-doleritic dykes and sills dated to about 700 m.y. were intruded into the Rocky Cape Group and Burnie Formation contemporaneously with folding (Cooee Dolerite and Penguin Orogeny; Spry, 1957, 1962; McDougall & Leggo, 1965; Gee, 1971).

Fold styles in the successions are broad and open to overturned and are broken by Precambrian high angle NE.-SW. thrusts and major E-W. transcurrent faults from Rocky Cape to Ulverstone. They show regional strikes trending from N.-S. (King Island, Hunter Island, Woolnorth) to NE.-SW. (Rocky Cape Group and Burnie Formation) and NW.-SE. at Badger Head. Recent mapping of Hunter Island (D. J. Jennings & F. L. Sutherland) shows that it consists entirely of largely unmetamorphosed Precambrian slate, siltstone, quartzose sandstone and rare dolerite dykes, folded into a broad domal structure elongated N.-S. and affected mainly by meridional faults.

Dolomites with thin basal conglomerates (900 + m thick) transgress onto the Rocky Cape Group around Smithton and are usually included in the Precambrian (Gulline, 1959; Spry, 1962; Gee, 1968), but may be early Cambrian. Conversely, some beds (with some dolomitic horizons) which are grouped with Cambrian successions, as at King Island and Port Sorell, may be Upper Precambrian (McDougall & Leggo, 1965; Gee & Legge, 1971).

Cambrian

Stratigraphically complicated, predominantly eugeosynclinal Cambrian successions occupy almost meridional depositional troughs on south-east King Island (Solomon, 1969), around Smithton (Gulline, 1959), between Penguin and Ulverstone (Dial Trough, Burns, 1964) and at Port Sorell and Beaconsfield (Gee & Legge, 1971). The thick sequences (up to 3,230 + m thick) include greywacke, siltstone, breccia, conglomerate, chert and basic to acid volcanic and intrusive bodies. Tilloids and pillow lavas occur on King Island and mega-breccias, chaos structures and pillow lavas occur in the Dial Trough. Beds within these sequences have been dated on marine faunas from late Middle Cambrian to late Cambrian at Smithton, Dial Trough and Beaconsfield (Banks, 1962). Late (?) Cambrian serpentinized and albitised ultramafic and mafic complexes intrude Cambrian and Precambrian rocks at Beaconsfield and between Forth and Ulverstone (Burns, 1964; Gee & Legge, 1971). Unconformities found between some of the successions and the overlying Ordovician suggest that they were folded in the late Cambrian to early Ordovician Jukesian Orogeny. Solomon and Griffiths (1972) have recently suggested that such movements and deposition of overlying conglomerate wedges may have resulted from the collision of the Precambrian blocks along the line of the main Cambrian volcanic arc, due to westward movement along a subduction zone. However, other possibilities are equally feasible on present evidence.

Ordovician-Lower Devonian.

West of the Tamar, folded Ordovician sediments of the Junee Group (almost 1000 m thick) occur at Beaconsfield, Melrose and Dial Range (Burns, 1964; Gee & Legge, 1971). The lower siliceous rocks pass from terrestrial fanglomerates to marine miogeosynclinal sandstone and limestone, dated on marine faunas from Lower to Upper Ordovician (Banks, 1962b).

East of the Tamar, the Mathinna Beds outcrop extensively through to NE. Tasmania and the Furneaux Islands (Jennings, D., 1967, Marshall et al. 1969; Gee & Legge, 1971; Sutherland &

Kershaw, 1971). The Beds represent deeper water lutites and turbiditic arenites, dated on sparse fossil evidence from Lower Ordovician to Lower Devonian (Banks, 1962c; Marshall et al., 1969; Strusz, 1972). They show low grade metamorphism developed with tight and overturned folding. NW.-SE. regional fold trends change to NE.-SW. trends on Flinders Island, similar to the offshore regional Palaeozoic trends in Bass Strait (Hocking, 1972, Fig. 2). Both the Junee Group and Mathinna Beds were folded during the Tabberabberan Orogeny, which Solomon and Griffiths (1972) suggest was probably related to collision between the Ordovician-Devonian continental margin and the Lord Howe block.

Upper Devonian-Lower Carboniferous

Post-orogenic granitic bodies intrude the folded basement rocks on King Island, Three Hummock Island and in batholithic dimensions in north-east Tasmania, from Scottsdale to the Furneaux Group and other islands on the Bassian Rise (McDougall & Leggo, 1965; Marshall et al., 1969; Sutherland & Kershaw, 1971). Radiometric K/Ar and Rb/Sr dating indicates Upper Devonian intrusive ages at Scottsdale and Clarke Island (370 ± 10 m.y.) and Lower Carboniferous ages (354-335 ± 5 m.y.) on Cape Barren, King and Three Hummock Islands (McDougall & Leggo, 1965; Tasm. Mines Dept., rept. in prep.). Contact metamorphic and mineralized aureoles are well developed on some granite margins (Marshall et al., 1969; Large, 1971) and late-stage doleritic dyke swarms of related age are commonly associated with the north-east granites.

Upper Carboniferous-Triassic

Near horizontal beds unconformably overlie the folded basement or eroded granite around Wynyard, Devonport, Tamar Valley and Gladstone (Burns, 1964; Gee et al., 1967; Gee & Legge, 1971). Basal Wynyard Tillite (300 + m thick) of possible Carboniferous age gives way to Permian marine beds (450 + m thick) containing freshwater horizons. These pass up into Triassic freshwater sandstones and shales in the Tamar Valley.

Jurassic

Sheets of tholeiitic dolerite, some greater than 200 m thick, intrude Permo-Triassic beds at Devonport, Tamar Valley, Waterhouse, Cape Portland and some off-shore islands (Burns, 1964; Jennings, D., 1967; Moore, 1969; Jennings, D. & Sutherland, 1969; Gee & Legge, 1971). The only direct evidence supporting the supposed Jurassic age is at Cape Portland, where the dolerite is cut by and disconformably overlain by Lower Cretaceous igneous rocks. Feeder sources for the dolerite have been suggested near Dulverton, south of Port Sorell, Sidmouth, Tomahawk and off Cape Portland (Burns, 1964; Jennings, D. & Sutherland, 1969; D. E. Leaman, pers comm.).

POST-BASS BASIN HISTORY

Late Mesozoic Tectonism and Igneous Activity.

Major Upper Jurassic rifting, sedimentation and basic magmatism along the Otway Rift Valley, initiated the tectonic activity from which the Bass and Gippsland Basins later originated as subsidiary *en echelon* grabens within the cratonic highs (Richards & Hopkins, 1969; Griffiths, 1971; Hocking, 1972). The strong north-westerly rifting which formed the Bass Basin, was accompanied by spasmodic late Jurassic to mid-Cretaceous potassic magmatism. This is represented by basic minettes on King Island (137 m.y.), by the K-rich porphyrites, lamprophyres and subaerial lavas at Cape Portland (91-103 m.y.) and possibly by trachytic rocks in Bass 2 well (McDougall & Leggo, 1965; Jennings, D. & Sutherland, 1969; Sutherland & Corbett, 1972; Sutherland, 1972b). Pre-Upper Cretaceous sediments probably occur in some of the earliest Bass Basin rifts (Richards & Hopkins, 1969). It might be expected that they contain igneous debris supplied from the adjacent igneous activity, as occurs in the U. Jurassic/L. Cretaceous Strzelecki Group in the Strzelecki Basin (Hocking, 1972).

Following the partial detachment of Tasmania during separation of the Australian and Antarctic cratons in the mid-Cretaceous (Griffiths, 1971), the potassic magmatism ceased. Widespread faulting and subsidence formed the main outlines of the Bass Basin as sea-floor spreading opened the Tasman Sea to the E. (80-60 m.y.; Hayes & Ringis, 1972a).

Early Tertiary Tectonism and Sedimentation

Large scale faulting had broken across the southern Bassian uplands by early Tertiary time, to form NW. trending rift wedges and grabens such as the Mersey and Tamar Structures (Burns, 1964; Gee & Legge, 1971; Sutherland, 1971a). These depressions formed major drainage outlets joining Bass Basin and became catchments for non-marine sediments, which fill them to at least 518 m at Pardoe Beach, 335 m at Port Sorell and 300 m in the Tamar Trough (Longman & Leaman, 1971). Recent geophysical work suggests that a further NW. trending filled graben, at least 600 m deep, intersects the NE. coast near Gladstone (D. E. Leaman, pers. comm.). There are also suggestions of strong EW. cross faulting down-stepping the coastal dolerite northwards along the SE. margin of the Bass Structure (see rock distribution in mapping of Moore, 1969; Jennings, D. & Sutherland, 1969; Jennings D., 1967), while cross-faulting on the Bassian Rise probably bounds the Furneaux Islands (Jennings J., 1959a; Kershaw & Sutherland, 1972). Judging from strong alignments of coastal volcanic fissures, NNW. faulting probably also bounds far north-west Tasmania (Sutherland, in prep.), terminating the western uplands against the King Island Ridge.

At the time of this faulting, the climate was conducive to lateritization and bauxitization of the upland surfaces, remnants of which are preserved on fault margins in the Tamar Trough underlying Paleocene and later sediments (Gee & Legge, 1971; Sutherland, 1971a).

The early sedimentation in the fault troughs formed an extension of the basal non-marine sedimentary complex of Bass Basin (Eastern View Complex, U. Cretaceous to lowermost U. Eocene; Richards & Hopkins, 1969); Paleocene to Upper Oligocene palynological dates are known in the Tamar Trough beds (Sutherland, 1971a). Major faulting bounding the Bass Basin ceased by early Eocene times, when Tasmania formed part of the Australian craton and active sea-floor spreading from Antarctica commenced about 55 m.y. ago (Griffiths, 1971; Weissel & Hayes, 1972). A marine basin interfingering with the non-marine sedimentation on the upland margins became fully established in the Bass Basin in late Eocene times and restricted transgressive seas deposited 150 + m of sediments (Richards & Hopkins, 1969).

Early to Mid-Tertiary Volcanism and Sedimentation.

With the onset of basic volcanism, lavas began to fill some of the drainage into the Bass Basin. The oldest identified eruptions form a sequence of subaerial alkali basalts (with olivine nephelinite) at East Devonport. Here, thin interbasalitic sediments below the top flow on the foreshore show a microflora apparently older than the mid-Tertiary *Cyatheacidites annulata* flora, but lacking all the characteristic Eocene *Proteacidites* spp., suggesting perhaps an U. Eocene to L. Oligocene age (W. K. Harris, pers. comm.). These basalts fill the Devonport Lead on the west side of the Mersey Graben. Flows may have spilled from or into the Northdown Lead, where the basaltic fill is overlain by U. Oligocene beds and intercalated basalt of the Wesley Vale Lead (Burns, 1964; Sutherland, 1969a).

The Tamar basalts (Sutherland, 1969b, 1971a) and the lower valley-filling flow at Burnie (Gee et al., 1967) overlie non-marine beds that extend below sea-level and contain mid-Tertiary *C. annulata* microfloras (W. K. Harris, pers. comm.). Unpublished palaeomagnetic data on the lower Tamar basalts (Wyatt, 1971) suggests Lower Tertiary cruptive ages which place this phase of sedimentation and volcanism in late Oligocene times. Other eruptions probably of comparable age include the coarse lava of The Nut and the lower basalts at Dial Point, Don Heads, Doctors Rocks and Woody Hill Point (based on palaeomagnetic data and/or stratigraphic position below lowermost Miocene marine beds; Gee et al., 1967; Gee, 1971, Wyatt, 1971). Thus, by late Oligocene time vigorous volcanism, both alkali basaltic and tholeiitic in character, had choked valley outlets from Circular Head to the Tamar Valley with flow sequences up to 200 m thick.

Miocene Marine Sedimentation and Volcanism

Marine transgressions on southern Australian margins flooded the Bass Basin in the Miocene, forming Bass Strait and depositing 900 + m of calcareous sediments in the basin and overlapping onto the uplands (Richards & Hopkins, 1969). Shallow, warm water marine beds are preserved up to 94 m above present sea-level on King Island, and at Cape Grim, Marrawah, Redpa, Montagu, Wynyard, Somerset, Cape Portland and Furneaux Islands (Hughes, 1957; Jennings, J., 1959b; Gulline, 1959; Spry & Banks, 1962; Quilty, 1965; Sutherland & Corbett, 1967; Gee et al., 1967; Sutherland & Kershaw, 1971; Gee, 1971; Quilty, 1972). The earlier subaerial basaltic fillings along the NW. coast were apparently sufficiently thick to block entry of the transgressive seas to many of the major valleys as they show an antipathetic distribution to occurrences of the marine beds (Fig. 2). A similar situation may have existed along much of the NE. coast, but lack of firm dating of these valley fills and widespread Quaternary coastal deposits in non-basaltic embayments obscure the picture. Around Cape Portland, where both subaerial basalts and off-shore marine and on-shore lagoonal (?) Miocene beds are known (Jennings, D. & Sutherland, 1969; Quilty, 1972), stratigraphic relationships and strong induration of marine rocks tentatively suggest some marine transgression prior to any blocking extrusions.

Extensive horizons of non-marine beds, above present sea-level and commonly separating the earlier basalts from later series, are widespread in the main leads from Smithton to Port Sorell, where they form the Wesley Vale Sand (Burns, 1964;

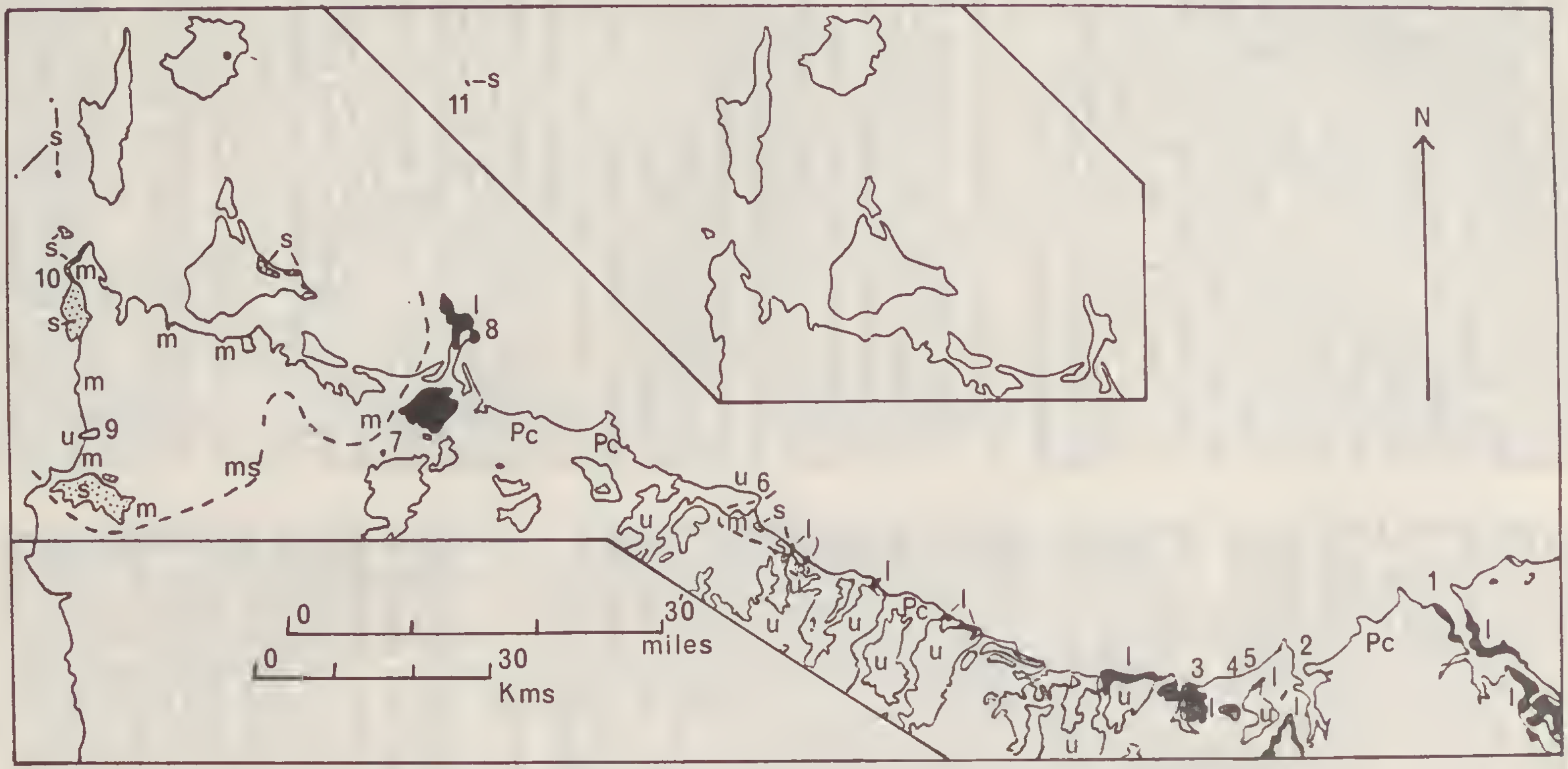

FIG. 2—Map of north-west Tasmania showing known age distribution of volcanic sequences as Lower Tertiary subaerial lavas (black, 1), Miocene subaqueous lavas (stippled, s) and Upper Tertiary and undifferentiated subaerial lavas (clear, u) and showing their relations to known Miocene marine beds (m) and rocky headlands of Precambrian rocks (Pc). The dashed line indicates the approximate southern limits of the Miocene marine transgression onto the Tasmanian coast. Some important localities described in the text include (1) Tamar lead, (2) Sorell lead, (3) Devonport lead, (4) Northdown lead, (5) Wesley Vale lead, (6) Table Cape, (7) Lileah, (8) The Nut, (9) Mt. Cameron West, (10) Cape Grim-Studland Bay, (11) Black Pyramid.

Gee et al., 1967; Gee, 1971). At Lileah, sub-basaltic sediments of this horizon, dated as mid-Tertiary, also contain planktonic microfloras of marine or brackish water origin (Harris 1968). Thus, these horizons occupy a similar elevation and stratigraphic interval, at least in part, to the Miocene marine beds and represent equivalent on-shore facies. They provide a useful interval to separate the early and late Tertiary volcanism.

In the areas of marine inundation, particularly in north-west Tasmania, its coincidence with continued prevalent volcanism, commonly tholeiitic in character, produced extensive submarine and coastal island eruptions (Sutherland & Corbett, 1967; Sutherland, in prep.). These provide the best range of Cainozoic aquagene volcanics known in Australia. Pillow (flow foot) breccias directly overlie the lowermost Miocene marine beds at Fossil Bluff, Doctors Rocks and Woody Hill, suggsting eruption into the early Longfordian seas at levels exceeding 75 m above present sea-level. At Cape Grim, early Longfordian marine beds overlie extensive hyaloclastites, pillow lavas and pillow breccias which extend 9 km along the coast to Studland Bay and suggest eruptions into seas at least 110 m higher than present sea-level. Around Marrawah and Redpa, late Longfordian to Batesfordian limestones widely underlie, but also contain older fragments of pillow breccias that were erupted into the Miocene seas to levels exceeding 120 m above present sea-level. At Brittons Swamp, a hyaloclastite basalt neck that contains fragments of Upper Longfordian marine beds, presumably erupted into the highest mid-Miocene sea. Similar aquagene volcanics occur on Robbins, Trefoil and Steep Islands, North and South Black Rocks, Black Pyramid and in the 'tuffite' cones in the mid-Tertiary marine sequence in Bass 2 well. They represent further volcanism, presumably mostly in high Miocene seas, erupting largely from NW. trending fissures. Black Pyramid, in particular, appears to show a classical sequence of an emerging volcanic island, with lower columnar pillowy lavas underlying bedded 'tuffs' and capping flow foot breccias, indicating seas at least 73 m above present level.

Late Tertiary Erosion, Volcanism and Sedimentation

Marine regression in the Miocene and early Pliocene rejuvenated the upland drainage, which strongly dissected the earlier high-level sediments and volcanics and formed outlets extending below present sea-level. Continuing eruption of extensive lavas formed thick, subaerial, predominantly alkali basalt, valley-fills such as those at Mt. Cameron West, Woolnorth Point and the broad lava plains along the NW. Coast from Smithton to Northdown (Gulline, 1959; Burns, 1964; Sutherland & Corbett, 1967; Gee et al., 1967; Gee 1971). Minor, basal flow foot breccias to these flows at Chambers Bay and Northdown Beacon may represent eruption into locally dammed drainage rather than into Miocene seas. Precise upper ages of these lavas are not known, but the deeply weathered and lateritized surfaces developed on them suggest that most, at least, are older than mid-Pliocene. An interesting problem arises in the relation of these lavas to the Miocene marine beds. Did the erosion and basaltic filling of the valleys post-date the early to mid-Miocene marine sedimentation on the uplands, or did some or all of it occur during a regressive phase within the Miocene marine transgression? A possible mid-Longfordian marine regression has been suggested by Quilty (1972). Precise dating of flows such as those at Mt. Cameron West and Table Cape, which cap dissected lowest Miocene marine beds to below sea-level, will be critical in resolving this problem.

Traces of benching on Bass Strait Island coasts at the 60-75 m levels may record old marine levels, possibly dating back to the Miocene high seas (Jennings, J., 1959b; Kershaw & Sutherland, 1972). There is no direct evidence of later Teritary marine transgressions on inner Bass Strait margins, but shallow transgression is suggested by Middle to Upper Pliocene marine beds up to 6·5 m in elevation on the east coast of Flinders Island (Cameron Inlet Formation; Sutherland & Kershaw, 1971). Palaeotemperature measurements on shells from this formation indicate sea temperatures up to 16·5°C, but cooler than the more tropical Miocene seas (Dorman, 1966; Quilty, 1972). Lateritic surfaces on the Lower Coastal Surface in north-west Tasmania (Davies, 1959) are developed on the Upper Tertiary basalts and this lateritization probably took place under pluvial tropical conditions which apparently existed until mid-Pliocene times.

Summary of Volcanism

The structural development of Bass Strait obviously influenced Cainozoic volcanism and the basalt distribution in Tasmania broadens northwards to encompass the whole length of the Bass Strait margin. A grandiose concept of a great central volcano occupying Bass Strait and issuing flows down into the peripheral Tasmanian valleys (Noetling, 1911, Pl. 11 Fig. 3) is now easily dismissed and a number of eruptive centres have been identified along the coast (Fig. 3). Some of

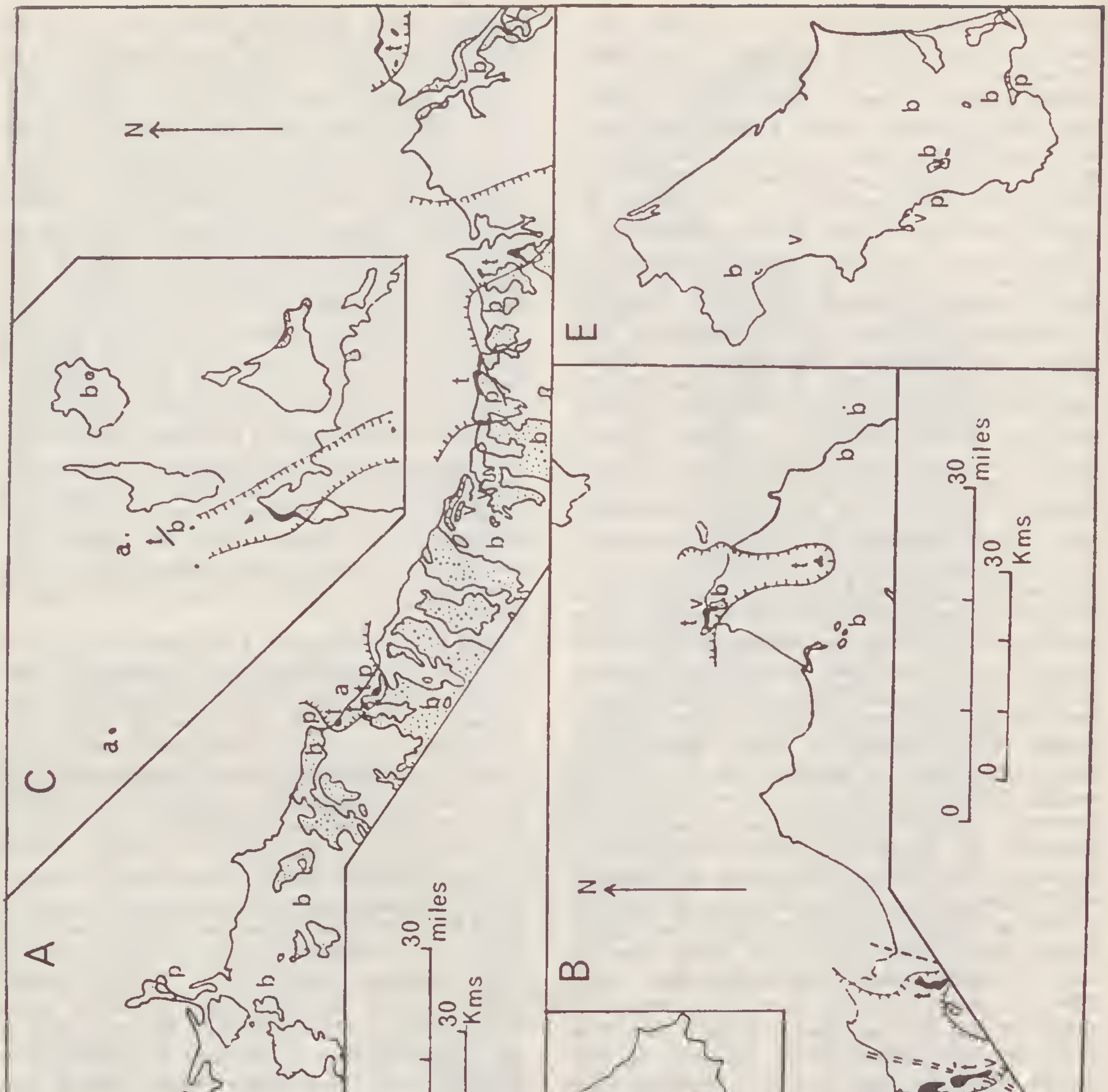

FIG. 3—Map showing distribution of alkali basalt (b) and tholeiitic basalt (t) associations along Bass Strait margins: (A) NW. to N. Tasmania, (B) N. to NE. Tasmania, (C) inset of far NW. coast islands, (D) inset of Cape Barren Island, (E) inset of Flinders Island. The hatchured line indicates approximate limits of the tholeiitic association. Known and probable eruptive centres are indicated as lava volcanoes (v), pyroclastic lava volcanoes (p) and aquagene volcanoes (a). The dashed line represents approximate limits of a probable underlying mantle high, with the double dashed lines representing the most pronounced part of the high (data from D. E. Leaman). Note the concentration of volcanism, particularly considerable tholeiitic volcanism, over this feature.

the spectacular promontories of coarse alkali basalt with differentiated phases (The Nut, Table Cape) have been considered large necks, but recent work suggests that they are probably deeply ponded lavas up to 135 m thick, resembling the coarse flows in the Tamar Valley (Sutherland, 1969b, 1971a; Cromer, 1972; unpublished observations).

A broad maximum of Tasmanian volcanic activity during Oligocene-Miocene times contrasts with the pattern found on the opposing Victorian margin (Sutherland, 1969a). It falls within a major phase of sea-floor spreading between Australia and Antarctica (Griffiths & Varne, 1972; Sutherland, Green and Wyatt, 1972) and more locally corresponds with two periods of relatively abrupt tectonic adjustment in the Bass Basin in late Oligocene and mid-Miocene times (Richards & Hopkins, 1969). Both alkali basaltic and tholeiitic lavas were generated, with tholeiitic eruptions concentrated in a mid-Cainozoic peak of activity (Figs. 2 & 3). The tholeiitic centres around Noland Bay appear to lie over a broad mantle high that increases in gradient towards Bass Strait (based on gravity data; D. E. Leaman, pers. comm.). This favours a higher level generation for the tholeiitic lavas than for the alkali basalts, while their tendency towards a concentration along the north coast suggests that some mantle upwarping may be a feature of the southern margin of the Bass Basin. Thus, the relative extent to which blocking action of earlier volcanism or later uplift and warping has determined the present distribution of the Miocene marine sedimentation on the Tasmanian margin needs further evaluation.

Quaternary Deposition and Erosion.

The Tasmanian side of Bass Strait appears to have remained relatively passive without any significant tectonism and volcanism since latest Tertiary times, in contrast to the Gippsland-Otway axis on the north side (Sutherland, 1971b; Sutherland, Green & Wyatt, 1972). There is little current seismic activity, but a westerly striking seismic zone extends across Flinders Island and Bass Strait from Long. 156° to 144° (Doyle, Everingham & Sutton, 1968). The coastal history has been mainly one of glacio-eustatic fluctuations combined with periods of extensive dune building in favourable situations.

The oldest known Pleistocene or latest Tertiary cool marine transgression occurs on the east coast of Flinders Island (Memana Formation, probably Werrikooian age; Sutherland & Kershaw, 1971) and has yet to be identified on inner Bass Strait shores. Levels associated with marine and littoral deposits have been measured at heights above present sealevel of about 37-45 m (King Island), 30-33 m (Sisters Creek, Ulverstone, Tamar, Bridport, Flinders Island), 20-23 m (King Island, Duck Bay, Rocky Cape, Ulverstone, Tamar, Flinders Island), 12-15 m (Rocky Cape, Ulverstone, Tamar) and 6-9 m (King Island, Rocky Cape, Bridport, Cape Portland): (Gill & Banks, 1956; Jennings, J., 1959b, 1961; Jones, 1965; Marshall et al., 1969; Jennings, D. & Sutherland, 1969; Chick, 1971, Sutherland & Kershaw, 1971; Kershaw & Sutherland, 1972). The levels between 6-23 m are usually assigned to the Last Interglacial seas and the higher levels to older interglacial seas. Deltaic and coastal palustrine deposits of Last Interglacial age are also known at City of Melbourne Bay, King Island and at Mowbray Swamp (37,500 + years; Gill & Banks, 1956; Jennings, J., 1959b; Dury, 1964).

Dune building dates back to the early Pleistocene or older and some consolidated dune limestones on Flinders Island contain derived Upper Miocene foraminiferal faunas (Sutherland & Kershaw, 1971). Regionally dune series tend to be calcareous on westerly and northerly facing shores, and siliceous on easterly and southerly facing shores, particularly on the larger Bass Strait Islands; possible reasons for such a distribution are discussed by Jennings, J., (1968) and Kershaw & Sutherland (1972). Parabolic orientations of dunes are generally consistent with wind directions similar to those of the present regimes and lagoons are commonly associated with the coastal dunes.

Marine regressions associated with glacial periods extended dune building and drainage outlets well beyond and below the present coasts (Edwards, 1941; Jennings, J., 1959a). The lowering in sealevel was apparently sufficient to link Victoria with Flinders Island (−46 m) and Tasmania (−64 m; Jennings, J., 1959a; Gill, 1971), allowing migrations and subsequent isolation of faunas during periods of interglacial high seas. Faunas extant on the north Tasmanian coasts during the Last Interglacial included those with giant and other now extinct marsupials found at King Island, Mowbray Swamp (37,760 years) and Scotchtown Cave (Gill & Banks, 1956; Jennings, J., 1959b; Hope, 1969).

Pebble and cobble deposits on beaches and in raised storm ridges are a feature of the coast around the mouths of the Forth and Mersey Rivers (Davies, 1959; Chick, 1971). They are considered to represent material washed down these rivers by glacial meltwaters associated with the Last Glacial and partly redistributed by later marine action. Probable Pleistocene fluvio-glacial deposits with a very high proportion of very large boulders are known in close proximity to the coast in the Forth Valley at Paloona (Burns, 1964).

The post-Glacial sea rise (18,000 to 6,000 years ago) isolated Tasmania between 15,000 to 11,000 years ago, finally drowning the coast to its present level, where 'drowned forests' are known at Badger Head Bay (7,380 ± 100 y. BP), Port Sorell and on Cape Barren Island (Jones, 1968; Gill, 1971). Beach ridge and fore dune systems, related to post-Glacial seas, line the present sandy coasts and have been studied at King Island, Black River, Ulverstone, Port Sorell, Greens Beach and Flinders Island (Gill & Banks, 1956; Jennings, J., 1959b; Davies, 1961; Chick, 1971; Kershaw & Sutherland, 1972). The ridge systems associate with and date from old shore lines between 1-3 m above present level and are considered to be mid-Holocene in age. Whether this level represents a higher sea, as has been suggested for similar levels on the Victorian coast (Jenkin, 1968: Gill, 1971), or results from local variations is at present a matter of debate (Chick, 1971; Kershaw & Sutherland, 1972; Gill & Hopley, 1972).

The isolation of Tasmania and the biogeographic effect on the mammal faunas of Bass Strait has been discussed by Hope (1969). Species now extinct in local populations have been recorded from sub-fossil remains found in cave deposits (dated 8,100-8,200 years in the Ranga Cave, Flinders Island) and sand blows (Hope, 1969; Sutherland & Kershaw, 1971). The Tasmanian Aborigine, similarly cut-off from his mainland origins has left his record on the present Bass Strait shores in midden sites and stone quarries, which date back to at least, 8,120 ± 165 y. BP at Rocky Cape Cave (Jones, 1968; Jennings, J., 1971; Sutherland, 1972a).

Extraneous, natural visitations in the Bass Strait record include sporadic arrivals of meteoric showers (Flinders Island tektite, Sutherland & Kershaw, 1971; Lefroy iron and Moorleah stone, Hodge-Smith & Chalmers, 1942) and occasional influxes of large pumice drifts (1962 South Sandwich Eruption, Sutherland, 1965).

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